NASA TECH BRIEF

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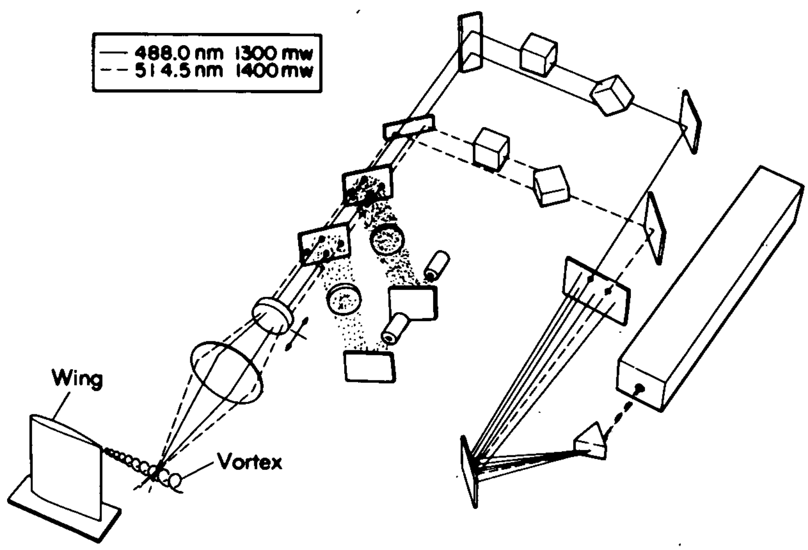
Laser Velocimeter for Simultaneous Two-Dimensional Velocity Measurements



Laser Doppler velocimeters are especially useful for the measurement of localized fluid velocities when perturbation of the flowfield is not desired. The basic principle of operation is that coherent laser light scattered from particulate matter in a fluid moving with a given velocity is Doppler-shifted by an amount dependent upon the laser wavelength in a vacuum, the index of refraction of the scattering medium, and unit vectors in the directions of the scattered and incident waves.

Modern laser velocimeters usually employ a crossed-beam system in which parallel incident beams are focused into the flowing stream through the same lens; light collected from the intersection volume at any angle contains a Doppler frequency which has its origin in an interference fringe pattern formed at the intersection region of the two incident beams. Such velocimeters are sensitive only to the component of velocity perpendicular to the bisector of the angle between the two beams and in a plane defined by the two beams.

It is often desirable to measure orthogonal velocity components simultaneously in order to evaluate turbulent shear stresses and, in general, to give a more complete description of the fluid flowfield under study. Laser velocimeters operating in the dual-scatter configuration have conventionally obtained two simultaneous orthogonal velocity components by masking the receiving optics or using polarization techniques to separate the two channels. Scanning of the fluid

(continued overleaf)

stream has been accomplished by translating the flow apparatus (keeping the velocimeter system fixed), by translation of the entire laser system about the flowfield, or by using reflective optics. However, these systems have disadvantages, such as those related to signal strength, speed, scope of operation, and mechanical problems.

A laser velocimeter has been developed which provides simultaneous orthogonal measurements in a manner which minimizes many of the problems attending prior systems, and allows spatial traversing of the flowfield in order to obtain velocity profiles.

The diagram indicates the optical layout of a laser velocimeter which is suitable for simultaneous two-dimensional velocity measurements. Inasmuch as an argon-ion laser produces several discrete radiation lines in the visible region, of which the two strongest are very nearly equal in intensity, a dense flint dispersing prism (index 1.72) and apertures are used to separate the two strong lines for operation of the velocimeter. Glass splitter blocks are used to divide the laser output into parallel beams of equal intensity; acousto-optic cells (with water-filled corrector cells to maintain parallelism of the two beams) are placed in one beam of each color to remove directional ambiguity from the velocity measurements. The beam pattern required for orthogonal velocities is produced by mirrors; light beams pass unimpeded through holes in the detection mirror substrates and are focused within the flow by an achromatic lens system.

Light backscattered at the test volume is collected by the converging lens and emerges parallel from the negative lens. At the dichroic mirror, one color is transmitted on to a second mirror while the other color is reflected; thus, using two photodetectors, simultaneous velocity information is available because light of wavelength 514.5 nm contains the Doppler information from which the horizontal velocity component can be computed, and the vertical velocity components can be obtained from the heterodyne information contained in the 488.0-nm light.

The scanning lens system must necessarily be achromatic because the two sets of crossed beams must focus at the same point at any distance. Moving the negative lens over small distances results in the scanning of the fluid stream over much larger distances. Both the negative and the positive lens are of low *f*-number with the following combination specifications: (a) Minimum distance to test point is determined by the diameter of the positive lens; (b) Maximum range is determined by the distance beyond which the received signal is too small to be detected accurately.

The laser velocimeter described above permits rapid interrogation of unsteady flows where the area of interest is of the order of one meter in extent and the flow does not vary appreciably over a time of about one second.

Note:

Requests for further information may be directed to:

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Patent status:

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning non-exclusive or exclusive license for its commercial development should be addressed to:

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